Surface Reflectance Mapping using Interferometric Spectral Imagery from a Remotely Piloted Aircraft

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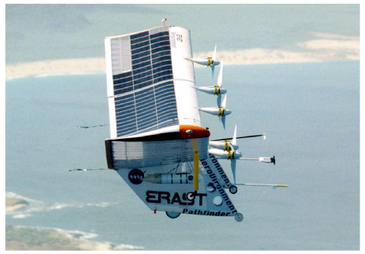
Background:

- Location: Pacific Missile Range Facility (PMRF), Kauai, Hawaii
- Date/time: 10/24/97, 13:20 local time
- Program: NASA's Environmental Research Aircraft & Sensor Technology (ERAST)
- Platform: Pathfinder - a Remotely Piloted Aircraft (RPA)
- Sensor: Digital Array Scanned Interferometer (DASI) hyperspectral imager

Objectives:

- General: Evaluate the feasibility of using RPA platforms to collect remotely sensed data in support of Earth systems science missions
- Specific: In-flight characterization of sensor, derivation of surface albedos, comparison of sensor derived quantities with ground measured quantities

Fig. 1, below: Pathfinder is a light-weight (~500 lb.) solar-powered Remotely Piloted Aircraft (RPA) with ~35 lb. payload capacity.



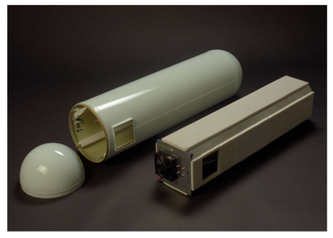


Fig. 2, above: Digital Array Scanned Interferometer (DASI) sensor next to RPA pod. Pod is mounted above "ERAST" in Fig. 1.

DASI characteristics:

- Compactness (pod is ~0.3m W x ~1.2m L), light weight, low power, rugged design, simplicity of operation
- Achieves spectral discrimination by 2-beam interference
- Spectral range: 0.45 to 0.80 μm
- Spectral resolution: ~250 cm^{-1} (10 nm at 0.65 μm)
- Cross-track FOV: 11 deg, 240 elements
- Surface spatial resolution: ~5 m typical
- Configured for remote operation

Fig. 3: False color image of PMRF from ARTIS/Kodak camera aboard Pathfinder. Near IR channel is rendered as red.

Fig. 4: Color photo, PMRF

Analysis:

- 20 regions were selected from DASI image of PMRF (Fig. 7). Comparisons of DASI and ground measurements were made near region 1, a concrete runway with uniform spectral properties.
- Surface albedos measured on ground (Fig. 5, 6) were transformed to effective DASI at-sensor radiance values using an atmospheric model (MODTRAN) together with radiosonde measurements. Comparison with DASI at-sensor radiance (adjusted with a spectrally independent multiplier) is shown in Fig. 8. This multiplier was applied to DASI laboratory calibration to compensate for radiance scale errors caused by in-flight malfunction of the adjustable entrance aperture.
- Surface reflectance values for all regions were derived from adjusted DASI at-sensor radiance measurements using the above model (Fig. 9).

Fig. 5: Ground measurement of surface albedo using Spectron SE590 spectroradiometer

Fig. 6: Albedo spectrum measured at surface: mean and ± std error

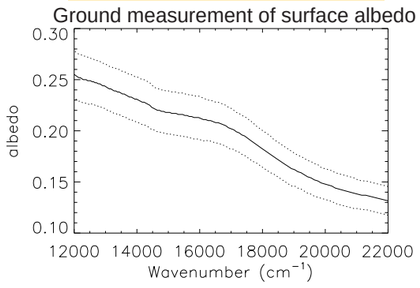


Fig. 7: Spectrally averaged, roll corrected DASI image of PMRF showing designated regions

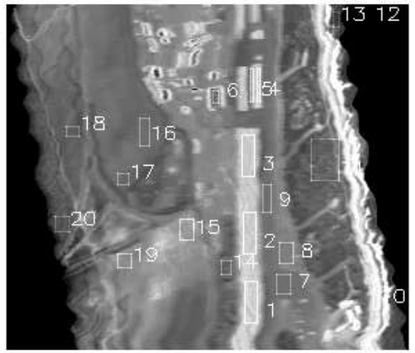


Fig. 8: DASI spectrum of region 1 (Fig. 7), and MODTRAN spectrum derived using albedo measured at surface (Fig 6) and atmospheric profile from a radiosonde.

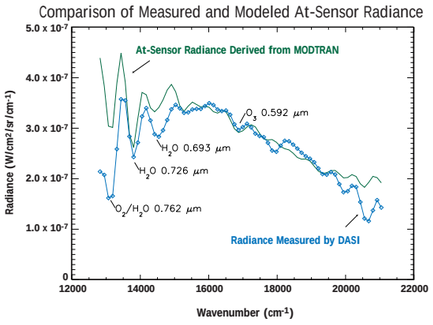
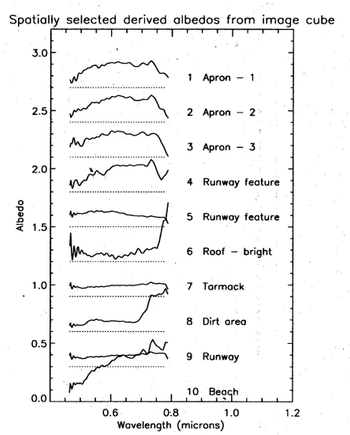
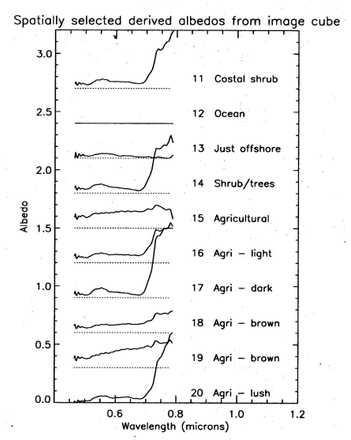


Fig. 9: DASI spectra of regions of Fig 7. Spectra 6 and 10 are severely distorted because of detector saturation. Region 8 has partial vegetation cover.





Conclusions:

- There is quantitative agreement between the airborne based and ground based measurements after adjusting for DASI radiance scale errors as described above (Fig. 8). The fine spectral discrepancies are attributable to saturation onset of the DASI for region 1.
- Based on laboratory radiometric calibrations and the above adjustment factor, reflectance spectra could be derived using MODTRAN for other regions of the image (Fig. 7, 9).
- The capability to obtain hyperspectral imagery from a remotely piloted aircraft has much future potential to support NASA's Earth science missions.

Future work:

- Mechanical and optical design improvements of DASI to enable stable radiometric calibration
- Upgrade detector array to improve dynamic range and signal-to-noise of sensor
- Improvement of in-flight operational procedures
- Carry out further airborne tests